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allowed to take any higher power objective than the one inch to any of the society meetings. Low powers and relatively familiar objects are what interest the amateur and the tyro, and it can not be expected that many members of a local society become experts.

DR. F. S. NEWCOMER.—I heartily endorse the proposition to send copies of this paper to colleges, that a decided step may be taken in developing the germ of investigation with the microscope. We must have more life and blood in this society, and we can get it only from our schools. What the Sunday school is to the church, the college microscopical society must be to this Society.

PROF. ALBERT MCCALLA said that the Agassiz Societies are doing a great deal of good in the way of illustrating the importance of revising college curricula so that they will contain more of the sciences and less of the impractical classics. The question was one that he was pleased to see discussed, because, as an educator, he felt that he would soon have to consider it.

DR. HUDSON said that no physician should attempt to diagnose a case of kidney disease, pyæmia, etc., without using the microscope. Hence, the importance of thorough training of pupils in the use of the instrument.

THE RELATION OF APERTURE TO AMPLIFICATION IN THE SELECTION OF A SERIES OF MICROSCOPE OBJECTIVES,

BY GEO. E. BLACKHAM. (PAGE 33).

PROF. W. A. ROGERS said: "The whole thing depends on the question 'Can we compute resolving powers?' I will not say that we can not and I have my doubts if we can. I question the truthfulness of the formula that is used in the computation. My confidence in it was shaken some time ago when in the measurement of some plates I found errors of one forty-thousandth of an inch. I think that the formula is true as far as it goes, but it does not tell the whole truth. There are conditions that affect it. Take, for instance, Bayard's formula for refractions. It is affected by the atmosphere and temperature. Now, I do not say that the two formulas are analogous; I use Bayard's only as an illustration of what may occur. My position is this: take what we have as a basis of investigation, and go ahead to ascertain the truth. There is a great sea for exploration in the question."

J. D. Cox said it seemed to him, that the discussion between advocates of wide and narrow angled objectives had no longer any intelligible meaning in the present state of science. The question is the simple practical one, what glasses are most efficient for our work? If it shall be found that the present theoretic tables of the limits of resolution are based upon inaccurate formulas, the practical question will remain the same. We shall still want the objectives which have the greatest possible resolving power, for no limit can ever be placed to the minuteness of detail in natural objects, and we can never say that we do not need wider angled glasses till we can affirm that we have sufficiently discriminated and examined the ultimate details of all things subject to microscopic examination.

The important fact which has been partly overlooked in the long debate is that the angle of aperture of an objective, is that which absolutely determines the limit in minuteness, of the details of objects which may be discriminated by it. You may choose whether you will examine details of fifty thousand to the inch (whether lines or other) with a half inch objective or a sixth, if the glass has the necessary angle; but they will be wholly invisible to you, no matter how well the lens may be corrected in other respects, if the objective has not the angle requisite.

The elements in which objectives may differ, assuming an equally good connection of the spherical and chromatic aberrations to be made, are three: 1. Angle of aperture. 2. Magnifying power. 3. Working distance.

The working distance is a matter of convenience in manipulation and may be quite variable. For all ordinary powers we say, in general, that the working distance should be the greatest that is compatible with the necessary angle of aperture.

The magnifying power must be sufficient to present the details under examination so that their image shall not demand of the naked eye the discrimination of parts smaller or closer (in the magnified image) than say a hundred and fifty to the inch. But this magnification may be secured by an objective and a two inch ocular, or another objective with a half inch ocular. Practical experiment will determine which glass will do it most satisfactorily.

The angle of aperture may be larger than is strictly necessary to discriminate and examine the details of a given minuteness, but it must not be smaller.

The combination of these three elements is thus shown to be a purely practical question, dependent upon the character and conditions of the work in hand. If we are looking for trichinæ in pork, it is enough to use a single lens arranged as several opticians have mounted it in a simple and special instrument; but if we want a microscope for general use we must seek a combination, and, to some extent, make a compromise of various qualities.

The statement of the problem thus seems to answer itself. Each investigator must determine in view of these conditions, what class of lenses will be most useful to him; but I believe Dr. Blackham has the verdict of experience with him when he says four or five lenses with a proper number of eye-pieces will cover the whole range of microscopical examination. In such a number of lenses you may get all the necessary combination of the three qualities of angle, power and working distance which you may need. Different investigators may choose different series, but no one need have a greater number in the series. Economy is to be considered in deciding whether we shall choose one or another lens, but this is also consistent with the statement that all the elements including economy, may be combined in such a small series. The lowest glass may be anything from a one-and-a-half inch to a three inch. If of an angle of 20° to 25° it will have plenty of working distance and penetration. The next glass should be of 40° angle, or very near it, as this is the maximum normal angle for binocular vision of opaque objects. Its working distance should be enough to allow the use of dissecting needles under it and the easy illumination of dry, opaque objects. These conditions are found in good glasses ranging from one inch to one half inch objectives. The third glass should also be a dry glass having working distance enough to accommodate work with the animalcule cages and compressors, and upon rough histological material. Its angle should be from 100° upward, to as wide an angle as is consistent with the necessary working distance. These conditions are found in glasses ranging from four-tenths inch objectives to one-sixth. Above the three lenses thus generally described, a single immersion lens of widest possible angle seems to give all the advantages that can be attained in the present condition of the art of making objectives.

In the third and fourth of the series, the angle should be the widest consistent with the other conditions specially named, and this is the only demand of the practical microscopist in which, as it seems to me, the phrase "wide angle" can have any appropriate place.

DR. BLACKHAM.—I agree almost exactly with every word Gov. Cox has said, but wish to add that I have been spoken of as a wide-angle maniac. The point of my paper is that it is worse than useless to employ in any given case any more of either aperture or amplification than is necessary for the work in hand, and my table includes objectives ranging from the very low aperture of 0.10 N. A. (= about 12 degrees air aperture) to the very highest N. A. attainable at present. In reference to my reasons of a limit to one-eighth or one-tenth, I wish to refer to one or two mechanical points. We all know that there is a limit to the mechanical perfection of all things human. If, then, we admit there is a certain necessary remainder of mechanical imperfection in the mechanical shaping of our lenses, then the same actual want of error is a greater proportional error in the minute front lenses of the higher power objectives, one-twenty-fifth, one-fiftieth, etc., than in the relatively larger lenses of the one-sixth, one-eighth, or one-tenth. The necessary area covered by the setting of the lenses is also greater proportionately in the smaller lenses of the one-twenty-fifth or one-fiftieth,than in the larger lenses, of the one-sixth, one-eighth, or one-tenth.

PROF. T. J. BURRILL.—I am very grateful for the discussion of this subject, so admirably treated in the remarks to which we have just listened, and in the paper presented yesterday. It seems to me that it satisfactorily settles the vexed questions so long waiting for clear and definite answer. We should all be thankful for the clearness of statement and carefulness of exposition which we now have presented to us. I wish to ask a single question. Is there anything in the nature of the light of the instrument by which a difference can occur in the vision of a single fine line under high magnification, from that of a series of fine lines, and is there, for instance, any difference in the attempt to bring out the flagellum of a bacterium from that of a series of equally fine parallel lines?

DR. BLACKHAM.—I would add a point on which Gov. Cox has not touched. It is hardly necessary to say to an audience like this that the retina is not a homogeneous sensory surface, but a number of very minute sensory points, the rods and cones separated by the pigment. If the image of a single line or point projected upon the retina falls upon one of these sensory points and the light is sufficient, we get a single sensation, and our consciousness becomes aware of the existence of a single line or point, and I think there is hardly a limit to the minuteness of a single line or point which can be seen as such under favorable circumstances; but if the image of two or more lines or points fall upon one and the same sensory point in the retina we only get a single sensation. In order to see two lines as two lines it is necessary that the two images should fall upon two different sensory points on the retina. It is thus quite possible that two lines, each of which can be easily seen alone, may be placed so close together that they can not be seen as two separate lines, or, to use the microscopical phrase, resolved.

DIVISION OF LABOR AMONG MICROSCOPISTS, BY J. M. MANSFIELD.

(PAGE 43.)

DR. FELL endorsed the views expressed in the paper. He believed that if work was laid out for many of the members of the society, it would be carried on much more systematically, and the results would be more complete. Two or more members might be assigned a certain field of labor, and their reports compared at the meetings of